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THESIS

"FLORA AND FAUNA ASSOCIATED WITH PRAIRIE DOG ECOSYSTEMS"

Submitted by

William Agnew

Department of Range Science

In partial fulfillment of the requirements

for the Degree of Master of Science

Colorado State University

Fort Collins, Colorado

Spring, 1983

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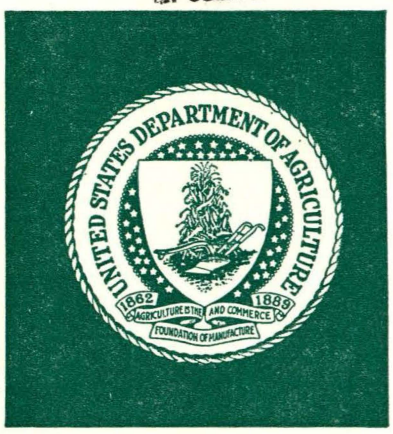

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY WILLIAM AGNEW ENTITLED FLORA AND FAUNA ASSOCIATED WITH PRAIRIE DOG ECOSYSTEMS BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

Committee on Graduate Work

Ronald A. Ryder

Ronald A. Ryder
Non-Department Committee Member

Daniel W. Uresk

Daniel W. Uresk
Co-Adviser

Richard M. Hansen

Richard M. Hansen
Co-Adviser

George Innis

Department Head

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ABSTRACT OF THESIS

"FLORA AND FAUNA ASSOCIATED WITH PRAIRIE DOG ECOSYSTEMS"

Vegetation, small mammals, birds and macroarthropods were sampled over two years on prairie dog colonies and mixed grasslands in western South Dakota. Prairie dog grazing favored an increase in forb production relative to percent canopy cover, although the number of forb species was greater on ungrazed mixed grasslands. Vegetative-litter cover and maximum vegetative height were significantly lower on prairie dog towns. Buffalograss (Buchloe dactyloides) was the dominant plant on prairie dog towns and western wheatgrass (Agropyron smithii) was most common on mixed grasslands.

Deer mice (Peromyscus maniculatus) and northern grasshopper mice (Onychomys leucogaster) were the most common small rodents of the seven species captured. They were more abundant on prairie dog towns than mixed grasslands. Prairie dog towns attracted more individual small mammals but a fewer number of species.

Avian density and species abundance was greater on prairie dog towns than mixed grasslands. Prairie dog clipping activity increased avian species associated with low cropped vegetation. Horned larks (Eremophila alpestris) were most common on prairie dog towns and western meadowlarks (Sturnella neglecta) on mixed grasslands.

Macroarthropod densities were highly variable throughout the growing season and between years on prairie dog towns and mixed grasslands. Ants (Hymenoptera Formicidae) were the most common macroarthropod on both treatments.

William Agnew
Range Science Department
Colorado State University
Fort Collins, Colorado 80523
Spring, 1983

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INTRODUCTION

The black-tailed prairie dog (Cynomys ludovicianus) inhabits prairie regions of the western United States. Its range originally extended from southern Canada to Mexico and was bordered on the west by the Rocky Mountains and on the east by the tall grass prairie (Bonham and Lerwick 1976). Prairie dogs are known to inhabit vast areas. In Texas, a single prairie dog colony was known to cover an area of about 25,000 square miles (Merriam 1901).

Black-tailed prairie dogs are diurnal herbivores and are active throughout the year (Lechleitner 1969). They are opportunistic and readily eat any abundant, nutritive food (Koford 1958). Buffalograss (Buchloe dactyloides), scarlet globemallow (Sphaeralcea coccinea), threadleaf sedge (Carex filifolia), blue grama (Bouteloua gracilis), and western wheatgrass (Agropyron smithii) were important food items in western South Dakota (Summers and Linder 1978).

The development of improved farming practices, including irrigation, led ranchmen to push farther westward over the semi-arid plains, until agriculture and livestock raising had invaded most parts of the prairie dog domain. Prairie dog feeding and burrowing activity conflicted directly with the interests of ranchmen (Merriam 1901; Uresk et al. 1982) and hastened large scale reductions in prairie dog populations. The present population is only a fraction of what it was a century ago (Bonham and Lerwick 1976).

Prairie dogs are still a problem for ranchers and range managers as they compete with cattle for forage plants (Hansen and Gold 1977). Intensive efforts to control prairie dog populations have been conducted for decades (Merriam 1901; Uresk and Bjugstad in press) and recently much time and money has been spent to control prairie dogs in the Conata Basin on the Buffalo Gap National Grassland of South Dakota. Black-tailed prairie dogs have expanded their range from an estimated 670 ha (1650 A) in 1968 to 6,340 ha (15,660 A) in 1976 on the Buffalo Gap National Grassland, prompting control measures (Collins et al. in press). Similar prairie dog expansion has taken place adjacent to these lands within Badland National Park with prairie dog colonies bordering and extending into adjacent privately owned land. Most of the prairie dog control effort has been by poisoning with zinc phosphide on whole oats after pre-baiting prairie dog colonies on Federal, State and private lands over large areas of rangeland (Schenbeck 1981). The impacts of a large poisoning program on small mammals, birds and macroarthropods has not been fully assessed. This study was designed to collect baseline information on small mammals, birds, macroarthropods and vegetation on prairie dog colonies, to assess the effect of future prairie dog poisoning.

The objectives of this investigation at the Badlands National Park, South Dakota were to compare:

1. Vegetative characteristics on prairie dog towns to that of native mixed grass prairie sites;

2. Small mammal densities and species composition on prairie dog towns to that of native mixed grass prairie sites;
3. Bird densities and species composition on prairie dog towns to that of native mixed grass prairie sites; and
4. Macroarthropod densities and taxa composition on prairie dog towns to that of native mixed grass prairie sites.

SITE DESCRIPTION

The study area was located in the Badlands National Park of west central South Dakota approximately 80 km east of Rapid City and 13 km southwest of Wall, South Dakota (Fig. 1). The climate is semiarid-continental and is characterized by cold winters and hot summers. The average annual precipitation, based on climatological information from Badlands National Park Cedar Pass Visitor Center weather station, is 397 mm, most of which falls during the growing season (April-September) (Table 1). The main source of rainfall during the growing season is high-intensity thunder showers, which produce a wide range of amounts and intensities of rain for any given location. Snowfall accumulations average 622 mm per year. The mean temperature is 10 C, ranging from -5 C in January to 26 C in July.

The soils are primarily sedimentary deposits of clay, silt, gravel and volcanic ash (Raymond and King 1976). Much of the landscape occurs in the form of steep gullies, sharp ridges, flat-topped buttes, spires, and pinnacles that are partly covered with vegetation and a smaller portion occurs as upland mixed grasslands. The gently sloping mixed grasslands are scattered throughout the area and represent the prime sites of prairie dog establishment within the park. The elevation of the study sites ranged from 820 m to 900 m.

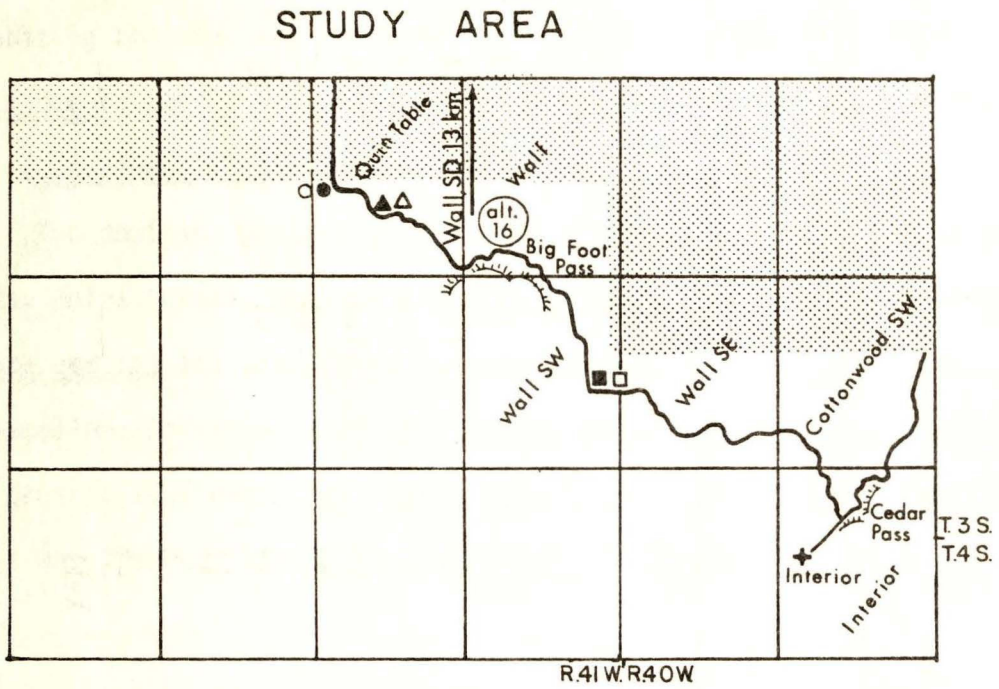

Figure 1. Map of the study area and reference to 7.5 minute topographic quadrangle maps for study sites in Badlands National Park, South Dakota.

Table 1. Monthly distribution of precipitation (mm) and mean temperature (C) at Cedar Pass Visitors Center Weather Station, Interior 3NE, South Dakota.

Month	Average 1951-1970 Precipitation	Average 1951-1970 Temperature	1981 Precipitation	1981 Temperature	1982 Precipitation	1982 Temperature
Jan.	4	-5	4	0	25	-10
Feb.	11	-2	3	-1	3	-3
March	17	2	2	6	36	3
April	41	9	17	13	13	8
May	79	16	64	14	185	14
June	94	21	68	21	74	18
July	55	26	86	24	103	24
Aug.	34	24	70	23	48	23
Sept.	31	19	6	19	55	18
Oct.	18	12	41	11		
Nov.	6	4	7	6		
Dec.	7	-2	12	-3	___	___
	Σ=397	$\bar{X}$=10	Σ=380	$\bar{X}$=11	Σ=	$\bar{X}$=

The study area is neither farmed nor grazed by domesti stock but has had livestock and farming in the past. Native inhabiting the area are American bison (Bison bison), pronghorn (Antilocapra americana), mule deer (Odocoileus heminus) and white-tailed deer (Odocoileus virginianus).

The dominant grasses of the area are western wheatgrass, blue grama, buffalograss, sun sedge (Carex heliophila), needle-and-thread (Stipa comata) and green needlegrass (Stipa viridula). Scarlet globemallow, American vetch (Vicia americana), sage (Salvia reflexa) and prairie sunflower (Helianthus petiolaris) are the most abundant forbs and fringed sage (Artemesia frigida) the dominant shrub.

METHODS

Vegetation, small mammals, birds and macroarthropods were sampled on a regular basis in 1981 and 1982. Six permanent 80 x 80-m (0.64 ha) study sites were chosen for determination of small mammal and macroarthropod densities and composition and vegetative characteristics and 6 adjacent permanent 805 x 62-m (4.9 ha) transects for birds. Three sites were established on prairie dog towns and 3 sites on mixed grass prairie sites adjacent to the respective prairie dog town (Fig. 1). The mixed grassland sites varied in proximity to the representative prairie dog town and ranged from 200 m to 1000 m apart. All sites were selected to be delineative of prairie dog towns and mixed grasslands respectively, with regard to vegetative characteristics. Representative prairie dog towns were selected with somewhat similar burrow densities and mixed grass prairie sites were selected to ensure against prairie dog invasion.

Vegetation

Vegetative characteristics were studied in three prairie dog towns and in adjacent mixed grass prairie control sites outside each town. Plant canopy cover, frequency of occurrence, maximum height and percent litter were estimated on 6 sites in 1981 and 1982. Plant canopy cover was estimated in 150 quadrats (20 x 50-cm)

placed at 1-m intervals along three 50-m line transects for each site (Fig. 2). Line transects were spaced 20-m apart. Canopy cover was visually estimated by the use of six cover classes: 1 = 0-5%; 2 = 5-25%; 3 = 25-50%; 4 = 50-75%; 5 = 75-95%; and 6 = 95-100% cover as described by Daubenmire (1959). Frequency of occurrence of each plant species was estimated by presence or absence for each quadrat. The tallest plant in each of the quadrats represented the height measurement. Percent litter was visually estimated by cover classes. Sampling was conducted three times during 1981 and three times during 1982, in June (late spring), July (summer) and August (late summer). Harrington (1964) and Nickerson et al. (1976) were used as the authorities for common and scientific names of plants.

Small Mammals

Small mammal populations were sampled in three prairie dog towns and in adjacent mixed grass prairie sites outside each town. Relative small mammal population estimates were made for each of the 6 sites by arranging 64 Sherman live traps (23 x 9-cm) in a grid design with 10-m spacing (Fig. 2). The grids were arranged to allow a 10-m border of similar habitat type to surround the trapping grid.

Trapping began in May and continued at three-week intervals through September of each year. Each session consisted of one night of prebaiting followed by four consecutive nights of trapping. Traps were opened in late afternoon on control sites and at dusk

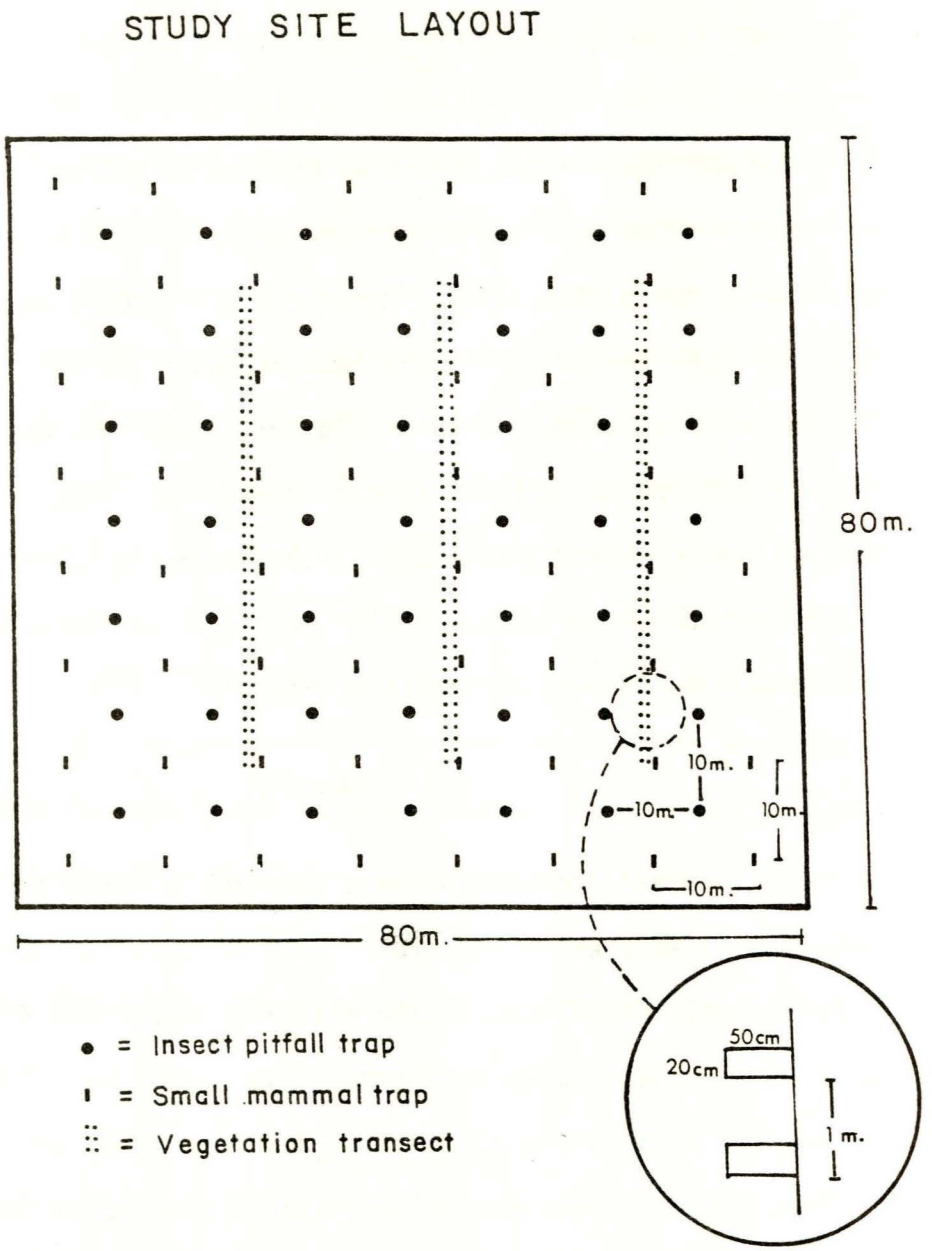

Figure 2. Experimental design for each study site showing locations of small mammal traps, macroarthropod traps and vegetation transects.

on prairie dog towns, to prevent the prairie dogs from closing the traps, and were checked at dawn on the next day.

A mixture of creamy peanut butter and rolled oats was used both inside and outside of the traps to attract small rodents. A sufficient supply of food, along with dacron batting, was placed in each trap to sustain the animal.

When the mammals were removed from the traps, they were identified as to species, sex, age, reproductive status and presence of parasites. The mammals were placed in a plastic bag and weighed with a spring scale then released. Each mammal was assigned a unique number by toe amputation as described by Taber and Cowan (1971). Hall and Kelson (1959) and Burt and Grossenheider (1976) were used as the authorities for common and scientific names for small mammals.

Burrow densities were mapped in June and September on each of the 6 sites in 1981 and 1982. Burrow mapping included all burrows on each of the prairie dog grids. The burrow densities on the control sites were estimated by establishing eight (50-cm x 50-m) permanent transect lines within the grid. All burrows along these transect lines were mapped and counted.

Birds

Avian populations were examined in three prairie dog towns and in adjacent mixed grass prairie sites outside each dog town. Bird censusing was conducted using a modified method similar to that of

Emlen (1971) and Emlen (1977). Six permanent strip transects, each 805-m in length and 62-m in width were established, one on each site. Each transect equalled 4.9-ha. Surveys were conducted on 4 consecutive days every three weeks, starting at sunrise and continuing for approximately 5 hours. Average walking time was 25-40 minutes per transect. All birds within each transect were identified visually or by vocalization and included birds which were flying through the transect during the census. Peterson (1961) and (A.O.U. 1982) were used as the authority for common names of birds.

Macroarthropods

Macroarthropod populations were sampled in three prairie dog towns and in three adjacent mixed grass prairie sites outside each dog town. Macroarthropod populations were sampled by using 15 x 15-cm metal can pitfall traps (Rogers et al. 1978). Forty-nine cans were buried flush with the soil surface in a grid at 10-m spacing on each site (Fig. 2). Pit traps were set for 4 consecutive nights at three-week intervals. Wooden lids were used to cover the traps and removed when trapping was initiated. Macroarthropod were removed, classified and counted. One specimen of each taxon was mounted in an macroarthropod collection. Borror and DeLong (1971) were used as the authority for the orders and families of macroarthropods.

Statistical Analyses

One, two and three-way analyses of variance (Nie et al. 1975) were used to compare relative abundance of small mammals captured.

One-way analyses of variance examined year, treatment, replicate and seasonal differences. Two-way analyses of variance included year by treatment, year by replicate, year by season, treatment by season and replicate by season differences. Three-way analyses of variance included only year by treatment by season differences. Two- and three-way analyses of variance, when concerning birds and macroarthropods, were used for individual species (birds) or order and family (macroarthropods) only.

Chi square contingency tables and Spearman's rank order correlation coefficient (Snedecor and Cochran 1973) were used to compare (all species or order-family) bird, macroarthropod and plant canopy cover. T-tests were used for total percent canopy cover, vegetative litter and maximum vegetative height measurements between years and between treatments.

RESULTS

Vegetation

Plant canopy cover ranged from 41% in late spring to 62% in the summer on prairie dog towns and from 59% to 67% during late spring and late summer respectively, on mixed grass sites (Table 2). Canopy cover was greater ($P<.001$) only in the late spring and late summer ($P<.05$) of 1982 when comparing prairie dog towns and mixed grass prairie sites (Table 2). Significant changes ($P<.005$) in canopy cover between years occurred only on mixed grass prairie sites and occurred throughout the growing season.

The amount of vegetative-litter cover was greater on mixed grass sites when compared to prairie dog towns during 1981 (Table 2). Litter ranged from 13% on prairie dog towns to 39% on mixed grass sites. A decrease in the amount of litter on mixed grass sites in the late spring of 1982 resulted in a non-significant ($P<.4$) difference in the percent litter when compared to prairie dog towns. However, litter on prairie dog towns decreased in summer and late summer and resulted in significant ($P<.01$) summer and late summer ($P<.001$) differences when compared to mixed grasslands. The between-year differences in litter were greatest ($P<.001$) on prairie dog towns during the summer and late summer and during the summer ($P<.05$) on mixed grass prairie sites.

Table 2. Mean (±SE) percent canopy cover, litter and maximum vegetative height of plants on a seasonal basis on prairie dog towns and on adjacent mixed grass prairie sites without prairie dogs in western South Dakota, in 1981 and 1982.

	Season					
	Late Spring		Summer		Late Summer	
Year	with[1]	without[2]	with	without	with	without
Canopy Cover (%)[3]						
1981	46±6	51±3	59±7	52±3	60±7	58±4
1982	35±5	67±3*	64±6	75±3	60±6	76±3***
Average	41	59	62	64	60	67
Litter (%)						
1981	21±2	40±4*	19±2	50±6*	17±.5	48±7*
1982	22±6	30±4	6±1	28±7**	8±1	34±6*
Average	22	35	13	39	13	34
Maximum Vegetative Height (cm)						
1981	8±.6	29±1*	12±.6	34±.9*	12±.3	36±.8*
1982	6±.2	24±.3*	13±.4	62±1*	12±.4	66±1*
Average	7	27	13	48	12	51

[1]With implies prairie dog town

[2]Without implies mixed grass prairie

[3]Canopy cover is 2-dimensional cover

*With vs without significantly different at $P<0.001$

**With vs without significantly different at $P<0.01$

***With vs without significantly different at $P<0.05$

Vegetative height measurements were greater ($P<.001$) on mixed grasslands when compared to prairie dog towns (Table 2). Vegetative height ranged from 7-cm in late spring on prairie dog towns to 51-cm in late summer on mixed grass sites. Vegetative height was significantly greater ($P<.001$) on mixed grass sites when comparing between years.

Buffalograss was the dominant plant species on prairie dog towns and provided 34% of the canopy cover (Table 4). Western wheatgrass and cheatgrass (Bromus tectorum) contributed 6% and 5% cover respectively and American vetch, Patagonia Indian wheat (Plantago spinulosa) and sage were common forbs each contributing 6% canopy cover. Fringed sage was the most important shrub and provided <1% cover.

Western wheatgrass and blue grama were the dominant plants on mixed grasslands and provided 24% and 17% canopy cover respectively (Table 4). The forb having the highest percent canopy cover was scarlet globemallow (2%) and fringed sage, a shrub, provided 2% cover.

Grasses and shrubs made-up a greater cover percentage on mixed grass sites when compared to prairie dog towns (Table 4). Percent canopy cover for forbs was higher on prairie dog towns, although the species composition was greater on mixed grasslands. A three-dimensional perspective of canopy cover shows seasonal and yearly variations in cover percentages, ranging from 60% on dog towns in the late spring to 102% on mixed grasslands in late summer (Table 3).

Table 3. Three-dimensional mean percent canopy cover by life forms of plants on prairie dog towns and on adjacent mixed grass prairie sites without prairie dogs in western South Dakota, in 1981 and 1982.

	Season					
	Late Spring		Summer		Late Summer	
Year	with[1]	without[2]	with	without	with	without
Canopy Cover (%)						
1981						
Grasses-Grasslikes	41	57	56	62	61	64
Forbs	19	10	26	6	35	10
Shrubs	<1	3	<1	5	1	6
Total	60	70	82	73	97	80
1982						
Grasses-Grasslikes	34	79	59	84	60	86
Forbs	26	18	38	12	27	11
Shrubs	<1	3	<1	4	1	5
Total	60	100	97	100	88	102

[1]With implies prairie dogtown

[2]Without implies mixed grass prairie

Table 4. Mean (±SE) percent canopy cover by life form of plants on prairie dog towns and on adjacent mixed grass prairie sites without prairie dogs in western South Dakota, 1981-82.

Species	With Prairie Dogs	Mixed Grass Prairie
Grasses		
Buchloe dactyloides	34±4	5±1
Agropyron smithii	6±<1	24±2
Bromus tectorum	5±1	4±2
Bouteloua gracilis	2±1	17±2
Schedonnardus paniculatus	2±1	<1±<1
Carex heliophila	<1±<1	7±1
Stipa viridula	0	6±1
Bromus japonicus	<1±<1	3±1
Muhlenbergia cuspidata	0	3±1
Stipa comata	<1±<1	3±1
Poa pratensis	0	2±1
Forbs		
Vicia americana	6±1	<1±<1
Plantago spinulosa	6±1	<1±<1
Salvia reflexa	6±1	<1±<1
Kochia scoparia	4±1	<1±<1
Euphorbia supina	2±1	<1±<1
Salsola kali	1±<1	<1±<1
Sphaeralcea coccinea	<1±<1	2±<1
Melilotus officinalis	<1±<1	1±<1

Table 4 Continued.

Species	With Prairie Dogs	Mixed Grass Prairie
Shrubs		
Artemisia frigida	1±<1	2±<1
Opuntia polyacantha	0	1±<1
	(Σ=54)	(Σ=75)

Plant species <1% include: Aristida longiseta, Vulpia octoflora, Carex filifolia, Setaria viridis, Hordeum pussillum, Agropyron cristatum, Koeleria cristata, Munroa squarrosa, Poa sandbergii, Sporobolus cryptandrus, Convolvulus arvensis, Dyssodia papposa, Hedeoma hispida, Chenopodium leptophylum, Aster falcatus, Amaranthus graecizans, Helianthus petiolaris, Lappula redowskii, Verbena bracteata, Solanum triflora, Polygonum ramosissimum, Solanum rostratum, Sisymbrium altissimum, Gaura coccinea, Lygodesmia juncea, Liatrus punctata, Taraxacum officinale, Draba reptans, Mirabolis linearus, Linus rigidum, Lepidium densiflora, Stellaria media, Penstemon albidus, Polygonum convolvulus, Aster eriocoides, Malva neglecta, Psoralea tenuiflora, Lomatium macrocarpum, Lithospermum arvense, Descurainia pinata, Bahia oppositifolia, Lupinus pusillus, Psoralea lanceolata, Erispimum asperum, Lilium sp., Plantago patagonica, Grindelia squarrosa, Viola nuttallii, Triodanis leptocarpa, Psoralea argophylla, Zigadenus venenosus, Oenothera caespitosa, Hymenoxys acaulis, Musineon divaricatum, Achillea millefolium, Allium textile, Anenome parviflora, Aster sp., Europhorbia marginata, Gutierrezia sarothrae, Rumex sp., Phlox hoodii, Artemisia ludoviciana, Opuntia fragilis, Mammalaria vivipara.

The rank order of all plant species (83) on the two treatments was significantly ($P<.01$) positively correlated ($r=.39$) for the two years.

Small Mammals

The total number of small mammals captured on all study sites was 674 in 1981 and 1,230 in 1982 (Table 5). Small mammals captured, in decreasing order of abundance were, deer mice (Peromyscus maniculatus), northern grasshopper mice (Onychomys leucogaster), prairie voles (Microtus ochrogaster), thirteen-lined ground squirrels (Spermophilus tridecemlineatus), western harvest mice (Reithrodontomys megalotis), hispid pocket mice (Perognothus hispidus) and house mice (Mus musculus). During 1981 and 1982, the mean rodent abundance on prairie dog towns was higher ($P<.005$) than on mixed grass prairie sites without prairie dogs (Fig. 3). The deer mouse was the most commonly trapped mammal in both years. Abundance of deer mice over the two years was greatest on prairie dog towns ($P<.005$) when compared to mixed grass sites and ranged from 29 to 9 on dog towns and mixed grasslands, respectively (Table 6).

Northern grasshopper mouse abundance stayed relatively constant between years on each of the treatments (Table 5). Mean abundance of northern grasshopper mice was greatest on prairie dog towns in 1981 and 1982 (Table 6). Mean captures, for both years were 12 on dog towns and 3 on mixed grasslands.

Table 5. Total number of small mammals on prairie dog towns and on adjacent mixed grass prairie sites without prairie dogs in western South Dakota, in 1981 and 1982.

Species	Individuals Captured 1981	1982
Peromyscus maniculatus	349 (52%)[1]	697 (57%)[1]
Onychomys leucogaster	207 (31%)	201 (16%)
Microtus ochrogaster	2 (<1%)	208 (17%)
Spermophilus tridecemlineatus	82 (12%)	67 (5%)
Reithrodontomys megalotis	16 (2%)	35 (3%)
Perognathus hispidus	16 (2%)	21 (2%)
Mus musculus	2 (<1%)	1 (<1%)
Total	674 (100%)	1,230 (100%)

[1]Percent of total capture

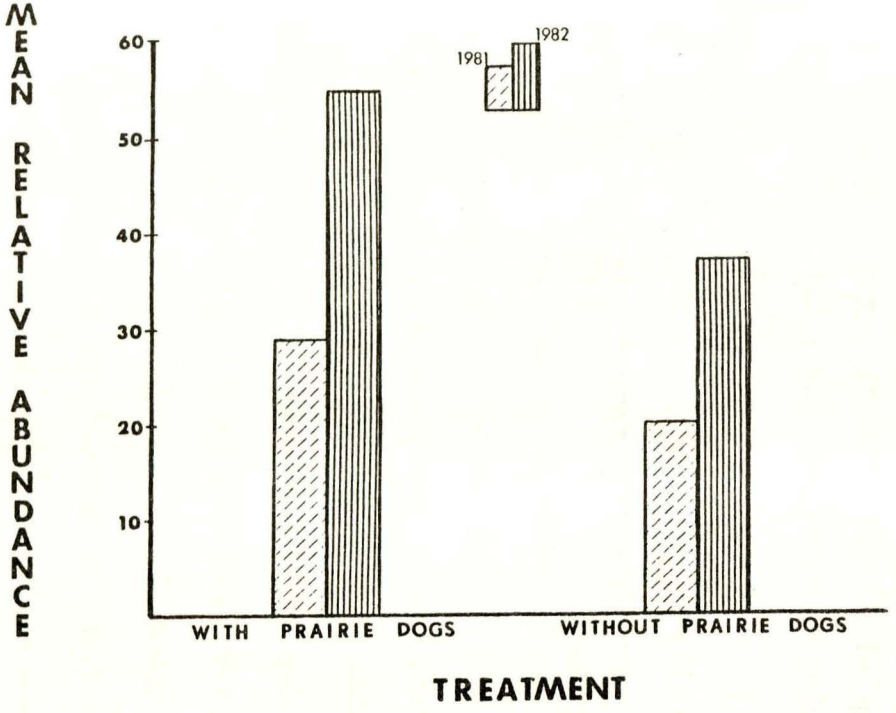

Figure 3. Mean relative abundance (numbers/1000 trap nights) of small mammals on prairie dog towns and on adjacent mixed grass prairie sites without prairie dogs in western South Dakota, in 1981 and 1982.

Table 6. Mean (±SE) relative abundance (numbers/1000 trap nights) of small mammals on prairie dog towns and on adjacent mixed grass prairie sites without prairie dogs in western South Dakota, 1981-82.[1]

Species	With Prairie Dogs	Mixed Grass Prairie
Peromyscus maniculatus	29±4[a]	9±2[b]
Onychomys leucogaster	12±2[a]	3±1[b]
Microtus ochrogaster	0[a]	8±2[b]
Spermophilus tridecemlineatus	<1±<1[a]	5±1[b]
Reithrodontomys megalotis	0[a]	2±<1[b]
Perognathus hispidus	0[a]	1±<1[b]
Mus musculus	<1±<1[a]	<1±<1[a]
Total	41[a]	28[b]

[1]The value with the same superscript (rows) were not significantly different ($P<0.005$)

Prairie voles were only captured on mixed grass prairie sites and showed the most dramatic population increases of any of the small mammals captured. Two individuals were captured in 1981, but vole numbers increased to 208 individuals in 1982, a significant ($P<.005$) increase (Table 6).

The thirteen-lined ground squirrel was captured most often in association with mixed grass sites and occurred infrequently on prairie dog towns. The abundance of ground squirrels ranged from <1 with prairie dogs to 5 on mixed grass sites (Table 6).

Western harvest mice and hispid pocket mice occupied mixed grass prairie sites only. The house mouse was captured on both prairie dog towns and mixed grass sites in low numbers. Western harvest mice and hispid pocket mice showed some increase in numbers from 1981 to 1982, though not significant. House mouse abundance stayed relatively constant (Table 6).

The relative abundance of small mammals was not significantly different on a seasonal basis, with the exception of the northern grasshopper mouse, whose numbers varied significantly ($P<.05$) in 1981 and 1982.

Small mammal burrows on prairie dog towns were limited primarily to the prairie dog burrow density. An average of 147 prairie dog burrows per ha were found on dog towns. Burrows on mixed grass prairie sites were dug primarily by small mammals other than prairie dogs. An average burrow density of 70 burrows per ha were found on mixed grass prairie sites.

Prairie dog towns attracted a greater number of mammals, other than those live trapped, than did mixed grassland sites. Commonly observed mammals on prairie dog towns included whitetail jackrabbits (Lepus townsendii), blacktail jackrabbits (Lepus californicus) and cottontails (Sylvilagus sp.). Weasels (Mustela sp.), striped skunks (Mephitis mephitis), coyotes (Canis latrans), badgers (Taxidea taxus) and porcupines (Erethizon dorsatum) were observed less frequently.

Birds

A total of 36 avian species were observed on prairie dog towns and 29 on mixed grass prairie sites without prairie dogs in 1981 and 1982 (Table 7). Total two-year avian densities ranged from 171 to 73 individuals on prairie dog towns and mixed grasslands, respectively. Bird abundance was higher ($P<.005$), in both years and throughout the growing season, on prairie dog towns when compared to mixed grass sites (Fig. 4). Bird numbers /5-ha on mixed grasslands ranged from a summer high of 152 in 1981 to a late summer low of 34 in 1981. The abundance of birds on prairie dog towns was also quite variable with a low of 114 in the summer of 1982 to a high of 298 in the late summer of 1982.

Horned larks (Eremophila alpestris) were the most common species on prairie dog towns in 1981 and 1982. Horned larks showed significant ($P<.001$) seasonal trends in both years and revealed a two year mean abundance of 97 on prairie dog towns and 2 on mixed grass prairie sites

Table 7. Mean (±SE) relative abundance (numbers/5 ha) of birds on prairie dog towns and on adjacent mixed grass prairie sites without prairie dogs in western South Dakota, 1981-82.

Common Name	With Prairie Dogs	Mixed Grass Prairie
Horned Lark	97±23	2±<1
Western Meadowlark	34±7	43±6
Mourning Dove	13±4	6±1
Killdeer	7±2	<1±<1
Barn Swallow	7±4	<1±<1
Burrowing Owl	3±1	0
Common Grackle	3±2	<1±<1
Red-winged Blackbird	2±1	6±2
Rock Dove	1±1	0
Upland Sandpiper	<1±<1	3±1
Lark Bunting	<1±<1	4±1
Grasshopper Sparrow	<1±<1	2±<1
Common Nighthawk	0	2±1
Unidentified	4±1	5±1
Total	171	73
	(Σ=36)	(Σ=29)

Bird species <1 per 5 ha include: Northern Rough-winged Swallow, European Starling, American Crow, House Sparrow, Eastern Kingbird, Marsh Hawk, Northern Pintail, Western Kingbird, Chestnut-collared Longspur, American Kestrel, Yellow-headed Blackbird, Loggerhead Shrike, Red-tailed Hawk, Mallard, Says Phoebe, Swainson's Hawk, Ferruginous Hawk, Long-billed Curlew, Blue-winged Teal, Prairie Falcon, Sharp-tailed Grouse, Turkey Vulture, Buteo spp., Vesper Sparrow, Great Horned Owl, Sora, Wilson's Phalarope.

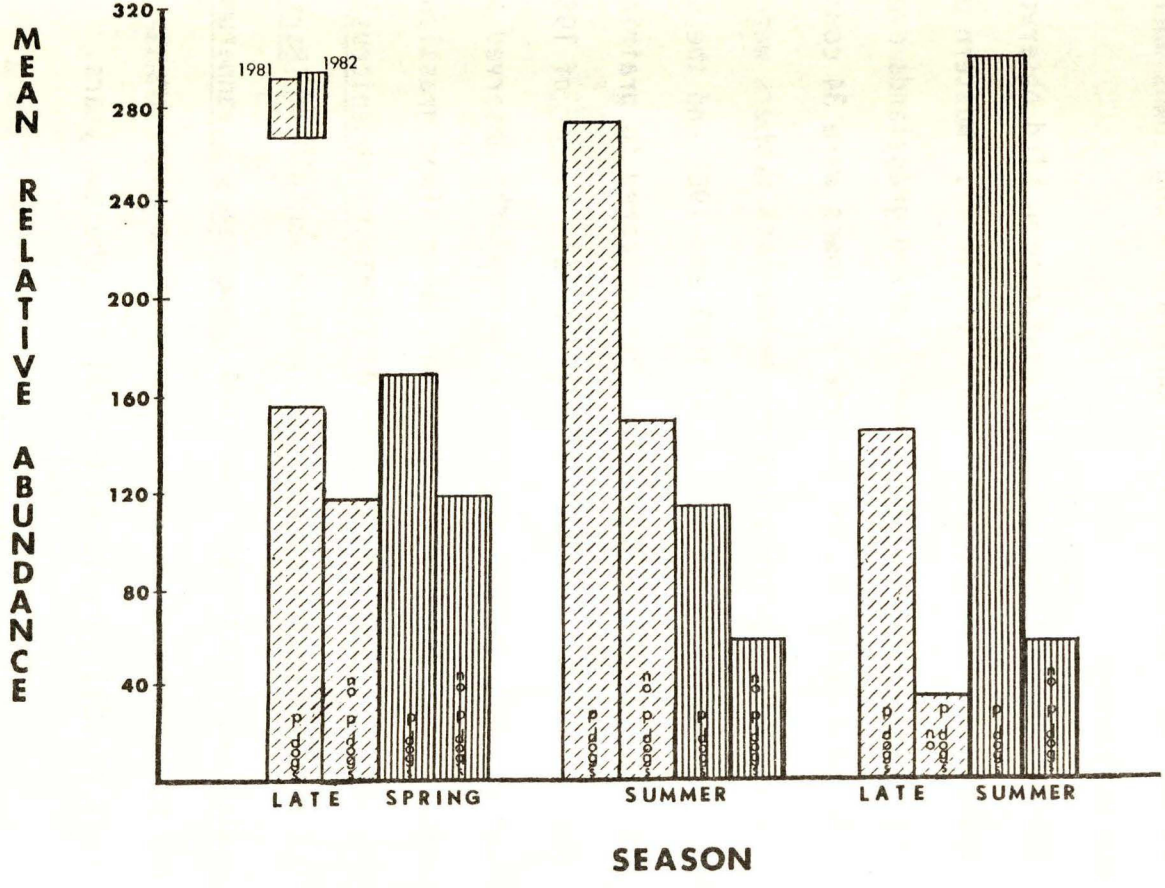

Figure 4. Mean relative abundance (numbers/5 ha) of birds on a seasonal basis on prairie dog towns and on adjacent mixed grass prairie sites without prairie dogs in western South Dakota, in 1981 and 1982.

which were significantly different (P<.001) (Table 7). Other birds commonly observed on dog towns were western meadowlarks (Sturnella neglecta), mourning doves (Zenaidura macroura), burrowing owls (Athene cunicularia) and killdeers (Charadrius vacitenus). Raptor observations were somewhat higher on prairie dog towns when compared to mixed grasslands.

Western meadowlarks were the most common bird observed on mixed grass prairie sites during both years (Table 7). Western meadowlarks were equally as common on dog towns as mixed grasslands over both years. Average densities on prairie dog towns were 34 compared to 43 on mixed grasslands. However, western meadowlark numbers were greater (P<.001), during the late spring of 1981 and 1982 and the summer of 1981, on mixed grass prairie sites when compared to prairie dog towns. This observation was reversed during the late summer of 1982, with a greater (P<.001) number of western meadowlarks observed on prairie dog towns. Other commonly observed birds on mixed grasslands include mourning doves, red-winged blackbirds (Agelaius phoeniceus), lark buntings (Calamospiza melanocorys), upland sandpipers (Bartramia longicauda) and grasshopper sparrows (Ammodramus savannarum).

The rank order of avian species on the two treatments was positively (P<.01) correlated (r=.43) for the two years.

Macroarthropods

The mean relative abundance of ground dwelling macroarthropods was highly variable throughout the growing season in 1981 and 1982 (P<.005), on prairie dog towns and mixed grasslands (Fig. 5).

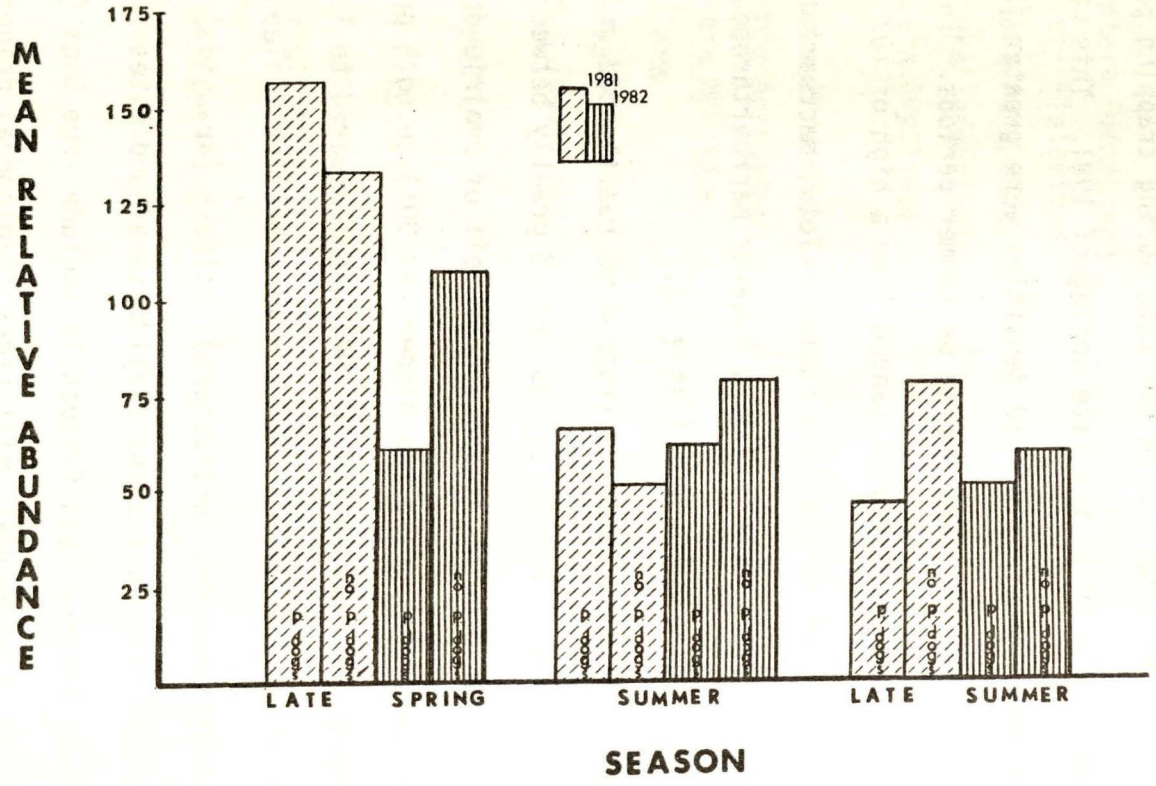

Figure 5. Mean relative abundance (numbers/.1 ha) of macroarthropods on a seasonal basis on prairie dog towns and on adjacent mixed grass prairie sites without prairie dogs in western South Dakota, in 1981 and 1982.

Macroarthropod numbers /.1 ha ranged from 156 in the late spring to 45 in the late summer in 1981 on prairie dog towns. In 1982, the densities remained relatively constant at 61 in the late spring and summer, then declined to 52 in the late summer. Macroarthropods on mixed grass prairie sites ranged from 132 in the late spring trapping period to 50 in the summer and 79 in the late spring of 1981. This was the only instance where macroarthropod densities were greater ($P<.05$) in the late summer than the late spring or summer periods. In 1982, the abundance of macroarthropods ranged from a high of 107 in late spring to a low of 60 in the late summer. Total macroarthropod numbers for both years were similar, however macroarthropod taxa composition was quite different (Table 8).

Ants were the most commonly trapped macroarthropod on both treatments (Table 8). Ant densities varied greatly between years and throughout the growing season, on and off of prairie dog towns. Ant abundance in late spring was higher ($P<.001$) on both prairie dog towns and mixed grass sites in 1981 when compared to 1982. Other commonly trapped macroarthropods were beetles (Coleoptera), crickets and grasshoppers (Orthoptera), spiders (Araneida), flies (Diptera), butterflies and moths (Lepidoptera) and mites (Acarina). Macroarthropods trapped less frequently include true bugs (Hemiptera) daddy-long-legs (Phalangida), millipedes (Diplopoda) dragonflies (Odonata), saw bugs (Isopoda) and centipedes (Chilapoda).

The rank order of macroarthropod taxa on the two treatments was positively ($P<.01$) correlated ($r=.68$) for the two years.

Table 8. Mean (±SE) relative abundance (numbers/.1 ha) of macroarthropods on prairie dog towns and on adjacent mixed grass prairie sites without prairie dogs in western South Dakota, 1981-82.

Macroarthropod taxa	With Prairie Dogs	Mixed Grass Prairie
Class Insecta		
Hymenoptera Formicidae	112±28	137±27
Coleoptera Histeridae	48±10	14±5
Coleoptera Carabidae	39±8	14±3
Coleoptera Tenebrionidae	18±4	21±5
Orthoptera Gryllidae	8±2	19±5
Diptera	5±1	12±6
Coleoptera Chrysomelidae	3±2	<1±<1
Orthoptera Acrididae	2±<1	16±6
Coleoptera Meloidae	1±<1	<1±<1
Lepidoptera	1±<1	7±2
Coleoptera Silphidae	<1±<1	5±2
Hemiptera Reduviidae	<1±<1	2±2
Class Arachnida		
Aranedia Lycosidae	19±6	36±7
Aranedia Thomisidae	5±5	<1±<1
Araneida Clubionidae	2±<1	2±<1
Acarina	2±1	14±8
Araneida Theridiidae	2±2	1±<1
Araneida Loxoscelidae	1±1	<1±<1

Table 8 Continued.

Macroarthropod taxa	With Prairie Dogs	Mixed Grass Prairie
Class Crustacea		
Isopoda	<1±<1	2±1
Class Chilopoda	<1±<1	<1±<1
Class Diplopoda	<1±<1	0
Total	267 (Σ=33)	295 (Σ=36)

Macroarthropods representing <1 per .1 ha include: Coleoptera Coccinellidae, Coleoptera Scarabaeidae, Hemiptera Lygaeidae, Coleoptera Curculionidae, Hymenoptera, Araneida Gnaphosidae, Hymenoptera Mutillidae, Hemiptera Anthocoridae, Hymenoptera Sphecidae, Coleoptera, Coleoptera Cerambycidae, Coleoptera Elateridae, Coleoptera Cinindelidae, Coleoptera Melyridae, Odonata, Phalangida.

DISCUSSION

Vegetation

The total number of plant species was greater on mixed grasslands when compared to prairie dog towns in 1981 and 1982. Species composition of grasses, forbs and shrubs was greater on mixed grass sites. In comparison, Koford (1958) and Bonham and Lerwick (1976) found a greater number of plants on prairie dog towns than on native shortgrass prairie sites. The lower number of plants on prairie dog towns may be attributed to a combination of factors: 1) prairie type; 2) preceding years with below normal precipitation; 3) below normal precipitation during the winter and spring of 1981; 4) soil differences; 5) prairie dog densities and diet; and 6) past farming and grazing practices.

Koford (1958) reported prairie dogs exert a significant influence on the successional patterns of the shortgrass prairie by decreasing plant biomass and altering species composition. Prairie dogs affect rangeland vegetation by removing a percentage of the herbage crop and by selectively influencing the abundance of various plants. Clipping of the vegetation by prairie dogs decrease the seed crop of plant species such as Russianthistle (Salsola kali), western wheatgrass and blue grama (Bonham and Lerwick 1976). However, such clipping resulted in a selective favoring of plants that were capable of responding by

rhizomes and stolons, such as buffalograss. Branson (1953) reported continuous clipping of tall and mid grasses by prairie dogs decreased the relative proportion of these grasses, favoring shortgrass species that are more tolerant to grazing. Prairie dog grazing lowers potential plant production by reducing or eliminating the tall or mid grass species which characteristically produce greater quantities of aboveground biomass (O'Meilia et al. 1982). However, Uresk and Bjugstad (in press) found vegetative aboveground biomass on prairie dog towns higher where only prairie dogs grazed than no grazing by either cattle or prairie dogs; or cattle grazing only; or grazing by both cattle and prairie dogs.

Prairie dog activity favored an increase in forb production relative to percent canopy cover. Koford (1958), Bonham and Lerwick (1976), Hassien (1976) and O'Meilia et al. (1982) found forbs to be more plentiful on prairie dog towns than outside dog towns.

Vegetative-litter cover was considerably higher on mixed grasslands with little or no herbivore use. Prairie dogs and other herbivores utilize the vegetation which does not allow the plants to grow and accumulate litter on the ground. The amount of total cover will have either a positive or negative affect on the soil temperature, plant growth and soil moisture or texture (Murie 1969).

Yearly and seasonal differences in canopy cover and vegetative height can be attributed to precipitation variations and grazing intensity (Stoddart et al. 1975). In 1982, the 35% increase in canopy cover and 82% increase in vegetative height, during the summer

and late summer on mixed grasslands, was related to the above normal precipitation throughout the year and little or no herbivore grazing. Canopy cover and vegetative height on prairie dog towns did not increase in 1982 as prairie dogs were utilizing the forage plants. Koford (1958) reported the vegetation on prairie dog towns is kept short by clipping an area 1,524 cm around the burrow. Prairie dogs clip any vegetation in their town which exceeds 15-cm in height, in order to maintain an unimpeded watch for predators (Hall 1955; Koford 1958; Tileston 1961). Clipping of vegetation by prairie dogs is an adaptation to ensure their own survival. Their activity may, however, render some animals more susceptible to predation (Birney et al. 1976) and limit their use of prairie dog towns, while others would benefit from prairie dog burrowing activity (Hansen and Gold 1977; O'Meilia et al. 1982).

Small Mammals

Total number of small rodents were greater on prairie dog towns than mixed grasslands. O'Meilia et al. (1982) stated that prairie dogs substantially influenced the biomass of rodent populations. Black-tailed prairie dogs are ecosystem regulators as they manipulate the soil and increase animal densities (Hansen and Gold 1977). Deer mice

and grasshopper mice probably benefit from the presence of unused prairie dog burrows which are available for shelter (Koford 1958; Smith 1967). Deer mice utilize ground burrows for nest and escape cover (Blair 1940). Prairie dog clipping and maintenance of vegetation in an earlier successional stage is particularly favorable to deer mice (Birch 1977).

Species abundance of small mammals was higher on mixed grass sites than prairie dog towns. Percent plant canopy cover and litter and vegetative height all influenced the abundance of small mammals on mixed grasslands. The value of vegetative cover as a habitat attribute can be organized into biotic and abiotic components (Birney et al. 1976). Biotic components include protection from predators, utilization of plants as a food source and conspecific behavioral influences on animals. Abiotic components include the influence of cover on microhabitats, precipitation and penetration of sunlight. Jameson (1947) and Carroll and Getz (1976) found prairie voles generally inhabit areas with dense stands of vegetation. Birney et al. (1976) found increased canopy cover had an important influence on increasing microtine populations. French et al. (1976) in studies of grassland habitats found the microtines associated with tall grass communities, the Scuirids associated with shortgrass communities and the Heteromyids associated with bunchgrass and desert

regions. Hull (1981) found the distribution of deer mice was correlated with total plant cover and macroarthropod densities. Maxwell (1973) and Honeycutt et al. (1981) found a positive correlation between rodent species diversity and plant cover diversity. Hardy (1945) found that depth and texture of soils directly influenced burrowing rodent distribution, however vegetation had a greater influence on their distribution. Soil characteristics seem associated with small mammal species diversity and abundance (Weins 1973).

Birds

Prairie dog clipping activity increased avian species associated with low cropped vegetation. Horned larks commonly inhabit open country with low sparse vegetation (Behle 1942; Trost 1972; Skinner 1975; Grzybowski 1980) and was the most commonly observed bird on prairie dog towns. Weins (1973) and Skinner (1975) found horned lark densities greater in grazed areas than ungrazed areas apparently in response to the lower vegetative height resulting from grazing. Burrowing owl's utilize abandoned prairie dog burrows as nest sites and escape cover (O'Meilia 1980).

Western meadowlarks were commonly observed on prairie dog towns and mixed grass sites. Lanyon (1956) reported the western meadowlark exhibited tolerance for a wide variety of plant associations, preferring large fields with short vegetation and good drainage. Grzybowski (1980) associated western meadowlarks with more dense vegetation.

Species diversity of birds was correlated with vegetative height (MacArthur and MacArthur 1961; MacArthur 1964; Recker 1969). MacArthur and MacArthur (1961) concluded there was a relationship between bird species diversity and plant species diversity, but only to the extent that the plant diversity was related to foliage height diversity. Similarly, Recker (1968) found a positive linear relationship between foliage height diversity and bird species diversity. However, Weins (1973) found no apparent relationship between bird species diversity and habitat heterogeneity or gradients from tallgrass through shortgrass ecosystems. Grzybowski (1980) found avian biomass estimates were higher on heavily grazed grasslands than lightly grazed grasslands in Oklahoma and western Texas.

A shift in western meadowlark abundance from mixed grasslands to prairie dog towns in the late summer of 1982, could be attributed to lower amounts of vegetative litter and lower vegetative height on prairie dog towns which would result in greater visibility of macroarthropods and seeds. Spring and summer diets of western meadowlarks consist primarily of macroarthropods with a shift to seeds in the fall and winter (Bryant 1914).

Prairie dog towns provided for a greater number of avian species and abundance than mixed grasslands. An increase in avian species in 1982 when compared to 1981 was, in part, due to above normal precipitation, and standing water, which resulted in an increased number

of waterfowl and shorebirds. Relatively close proximity to old abandoned farmsteads and windbreaks may have also contributed to the greater species abundance on prairie dog towns. Willson (1974) stated the addition of trees in a vegetational series has a disproportional effect on the addition of species.

Macroarthropods

Macroarthropods are a dynamic but poorly understood component of the rangeland ecosystem (Hewitt et al. 1974). Macroarthropod captures on prairie dog towns and mixed grasslands were highly variable throughout the 1981 and 1982 study periods. Borror and DeLong (1971) reported macroarthropod distribution as species specific and highly variable between localities. Temperature and moisture often act together to limit the number or distribution of macroarthropods (Mills 1952). Macroarthropod populations are cyclic in nature and can severely damage range vegetation and croplands (Shotwell 1941). Prairie dogs, in creating habitat for insectivorous mammals and birds, may indirectly reduce localized macroarthropod outbreaks. O'Meilia et al. (1982) reported macroarthropod biomass was three times greater on control plots without prairie dogs than dog towns. Total macroarthropod densities in this study slightly favored mixed grasslands.

Murdoch et al. (1972) found a weak correlation between plant species diversity and macroarthropod diversity, but a strong correlation between foliage height diversity and macroarthropod diversity.

Hull (1981) found no significant correlation between percent plant canopy cover, litter, bareground, or aboveground biomass and ground dwelling macroarthropod densities. The factors regulating macroarthropod distribution in the study area were not determined.

SUMMARY

Percent plant canopy cover, litter cover and vegetative height was greater on mixed grasslands than prairie dog towns. Grasses and shrubs made up a greater cover percentage on mixed grass sites when compared to prairie dog towns. Percent canopy cover for forbs was higher on prairie dog towns, although species composition was greater on mixed grasslands.

Buffalograss was the prominent plant on prairie dog towns, although other grasses such as western wheatgrass and cheatgrass and forbs such as American vetch, Patagonia Indian wheat and sage were common. Western wheatgrass and blue grama were dominant grasses and scarlet globemallow the dominant forb on mixed grass prairie sites. Fringed sage was the dominant shrub on both treatments.

Deer mice and northern grasshopper mice were the most commonly trapped small rodents on prairie dog towns and mixed grasslands. Prairie vole densities increased dramatically from 1981 to 1982 on mixed grasslands. Individual captures were higher on prairie dog towns, although the number of species were greater on mixed grass sites.

Avian densities and the number of species were greater on prairie dog towns than mixed grasslands. Seasonal fluctuations in populations were observed on both treatments. Horned larks were the most common species on dog towns and western meadowlarks on mixed grass prairie sites.

Macroarthropod densities were highly variable throughout the growing season and between years on both treatments. Generally, macroarthropod numbers were highest in the late spring and decreased through the summer. Ants were the most commonly trapped macroarthropod, although beetles, crickets and spiders were frequently captured.

Overall, plant production and the total number of plant species were greater on mixed grasslands than prairie dog towns. Mammals and birds were more abundant on prairie dog towns when considering all species observed. Macroarthropod densities slightly favored mixed grasslands.

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Typist: Mrs. Bunny Jewert
271 Aylesworth Hall, SW
491-6432

or

3847 Royal Drive
Fort Collins, CO 80526
226-5709